

SECTION 15970

DIRECT DIGITAL CONTROL SYSTEM

PART 1 - GENERAL

1.1 GENERAL CONDITIONS

- A. The General Provisions of the Contract, including General and Supplementary Conditions apply to the work specified in this Section.

1.2 WORK INCLUDED

- A. Provide a Building Control System (BCS) incorporating Direct Digital Control (DDC), energy management, and equipment monitoring and control, consisting of the following elements:
 - 1. Microcomputer based Digital Control Panel (DCP) interfacing directly with sensors, actuators and environmental delivery systems (i.e., HVAC units, boilers, chillers, etc.).
 - 2. Electric controls and mechanical devices for all items indicated on drawings and described hereinafter including dampers, valves and panels.
 - 3. Where more than DCP is required, a two-wire peer communication network to allow data exchange from DCP to DCP at a minimum rate per second of one megabit.
 - 4. Points required by either the sequence or the diagrams shall be included even if not indicated in both places.
- B. The BAS/ATC contractor shall be responsible for fully interfacing to the existing facility work station(s), (located remote to the building) at no additional cost to the owner. This includes software updates for a minimum of one desktop computer and one laptop computer.
- C. The contractor shall provide a logical presentation of graphical displays with the following higher hierarchical levels:
 - 1. Overall site plan: Provide a graphic depicting an overall site plan showing all buildings being monitored. Each building shall contain a transfer, which will allow the operator to penetrate each respective building.
 - 2. Floor plan graphic: Provide a graphic depicting each floor or zone contained in that building. Each screen shall contain transfers to other floors or zones, as well as backed to the overall site plan.
 - 3. Mechanical Systems: Provide a graphical schematic for each mechanical system shown on the drawings. Each sensed or controlled physical point shall be dynamically displayed. Each screen shall contain transfers to building floor plans or zones, as well as backed to the overall site plan.
- D. Submittals, data entry, electrical installation, programming, start up, test and validation, instruction of Owner's representative on maintenance and operation, as built documentation, and system warranty.
- E. Laptop Computer: Provide 2.0 GHZ, USB, Ethernet and RS232 port, 17" display, CD RW x

24 drive, 60 GB hard drive, 2.0 GB ram internal 56K modem, internet ready, wireless capable, and printer port. Provide with vendors full software package for maintenance and system control from remote locations.

- F. Front End Computer: Provide non-integrated 2.0 GHZ, Ethernet port, RS 232 port, printer port, CD RW x 24 drive, 60 GB hard drive, 2.0 GB ram internal 56K modem, (2) USB ports, internet ready, wireless capable, 17" LCD monitor, mouse, keyboard, (2) speaker audio. Provide manufacturer's latest front end software package, update any existing school DDC interfaces to new software version.

1.3 PRODUCTS FURNISHED BUT NOT INSTALLED UNDER THIS SECTION

- A. Section 15060 - Pipe and Pipe Fittings: Installation of control valves, temperature sensor wells, gauge taps.
- B. Section 16220 - Conductors: Installation and connection of all power wiring. Power wiring shall be defined as follows:
 - 1. Wiring of power feeds through all disconnects and starters to electric motors.
 - 2. Wiring of any remote start/stop switches not furnished by the BCS Contractor.

1.4 QUALITY ASSURANCE

- A. The system shall be installed by competent mechanics, regularly employed by the BSC manufacturer or an approved authorized agent with full responsibility for proper operation of the BSC including debugging and proper calibration of each component in the entire system.
- B. Major DDC components such as standalone control units shall be directly manufactured by the approved manufacturer and may not be the product of another manufacturer resold under the approved manufacturer's name.
- C. Supplier shall have an in-place support facility within 30 miles of the site with technical staff, spare parts inventory and all necessary test and diagnostic equipment.
- D. Codes and Approvals:
 - 1. The complete BCS installation shall be in strict accordance to the national and local electrical codes and the electrical section of these specifications. All devices designed for or used in line voltage applications shall be UL listed.
 - 2. All microprocessor based devices shall be UL916 listed.
 - 3. All electronic equipment shall conform to the requirements of FCC regulation Class B Part 15, Section 23 governing radio frequency electromagnetic interference and be so labeled.
- E. All system components are to be designed and built to be fault tolerant.
 - 1. Provide satisfactory operation without damage at 110% above and 85% below rated voltage and at +3 hertz variation in line frequency.
 - 2. Provide static, transient, and short circuit protection on all inputs and outputs. Communication lines shall be protected against incorrect wiring, static transients

and induced magnetic interference. Bus connected devices shall be a.c. coupled or equivalent so that any single device failure will not disrupt or halt bus communication.

1.5 SUBMITTALS

- A. Submit shop drawings and product data in accordance with Section 15000 Mechanical General Provisions.
- B. Identification of devices on shop drawings shall be the same as those used in the Contract Documents. Control submittals shall contain the following:
 - 1. Schematic of each item of mechanical equipment, locating each control component on its respective unit with proper termination point identifiers (including legend). One Schematic shall be included for each air handling system.
 - 2. Each schematic shall also have a corresponding wiring diagram in ladder form. Each schematic shall have an equipment list detailing all hardware components used. The list shall include:
 - a. Schematic Control Symbol
 - b. Quantity
 - c. Manufacture's Part Number
 - d. Tech Sheet Reference (include in submittal)
 - e. Description of Part
 - 3. Data sheets for each hardware component.
 - 4. Valve and well and tap schedules showing size, configuration, capacity and location of all equipment.
 - 5. Each DCP shall be detailed in the submittal to identify termination boards within each panel and terminal of their respective fields points. Each termination point shall define the point name and point description by each terminal within the DCP. Point names and descriptors shall be constant throughout the submittal on the schematics, wiring diagrams, equipment list, etc.
 - 6. A report shall be included in the submittal to include every point:
 - a. Point Name
 - b. Point Type (analog, digital, etc.)
 - c. Point Descriptor
 - d. Physical Address (enclose legend)
 - e. Alarm (yes or no)
 - f. Display Alarm (yes or no) - message displayed for each alarm
 - g. High Limit
 - h. Low Limit
 - i. Totalized (yes or no)
 - j. Hours or Minutes Totalized
 - k. Engineering Units of Point
 - 7. Data entry forms for initial parameters. Contractor shall provide English listing of all analog points with columnar blanks for high and low warning limits and high and low alarm limits, and a listing of all fan systems with columnar blanks for beginning and end of occupancy periods; and samples of proposed text for points and messages (for at least two systems of at least 15 points total). All text shall be approved prior to data entry.
 - 8. Software design data including:

- a. Flowchart of each DDC program showing interrelationship between inputs, PID functions, all other functions, outputs, etc.
 - b. English language sequence of operation relating to all flowchart functions.
- 9. Laptop computer and field maintenance software.

C. Operation and Maintenance Manual

- 1. CD of program including graphics
- 2. DDC software
- 3. DDC hardware (including terminal sensors)
- 4. Valves
- 5. Dampers

PART 2 - PRODUCTS

2.1 COMPUTERS AND SOFTWARE

- A. Refer to paragraphs 1.2 E. and 1.2 F.

2.2 MATERIALS

- A. All materials and equipment used shall be standard components, of regular manufacture for this application. All systems and components shall have been thoroughly tested and proven in actual use. It is the intent to use the most current manufacture of the sources identified such as Trane Tracer Revision 14.0 and Landis & Gyr Powers 600 Series Version 12.2. No other manufacturers are acceptable. Exceptions to the specifications will qualify the bid as unacceptable.

2.3 GENERAL

- A. The Building Automation System shall include but not be limited to the following components.
 - 1. The Operator Interface shall consist of hardware and software that allows full user monitoring and adjustment of system parameters.
 - 2. System Application Controllers shall manage the Energy and Building Management capabilities of the automation system and have capability to be adapted to facilitate remote communications and central monitoring.
 - 3. Custom Application Controllers with distributed custom programming capability shall provide control for nonstandard control sequences.
 - 4. The Data Communications capability shall allow data to be shared between the various controllers in the architecture.
 - 5. The system software shall include system software for global application functions, application software for distributed controllers, and operator interface software.
 - 6. End devices such as sensors, actuators, dampers, valves, and relays.
 - 7. Manufacturer's latest software for full access and control on a minimum of one laptop and one desktop computer.
 - 8. (1) maintenance laptop, refer to 1.2.
 - 9. (1) desktop computer, refer to 1.2.

- B. The failure of any single component shall not interrupt the control strategies of other operational devices. System expansion shall be through the addition of end devices, controllers, and other devices described in this specification.

2.4 BUILDING CONTROL PANEL MODEM ETHERNET INTERFACE

- A. System architecture shall provide separate ports for Ethernet, and portable laptop. Manual switching from Ethernet, to portable laptop on a single port is not acceptable.

2.5 SYSTEM APPLICATION CONTROLLERS (SAC)

- A. The Building Automation System shall be composed of one or more independent, stand-alone, microprocessor based System Application Controllers to manage the global strategies described in Application software section.
- B. The System Application Controller shall have ample memory to support its operating system, database, and programming requirements.
- C. The operating system of the System Application Controller shall manage the input and output communications signals to allow distributed controllers to share real and virtual point information and allow central monitoring and alarms.
- D. Data shall automatically be shared between System Application Controllers when they are networked together.
- E. The database and custom programming routines of remote System Application Controllers shall be editable from a single operator station.
- F. The System Applications Controllers shall have the capability to be remotely monitored over telephone modem. Additional capabilities shall include automatically dialing out alarms, gathering alarms, reports and logs, programming and downloading databases.
- G. The controller shall continually check the status of all processor and memory circuits. If a failure is detected, the controller shall:
 - 1. Assume a predetermined failure mode.
 - 2. Emit an alarm.
 - 3. Display card failure identification.

2.6 APPLICATION SPECIFIC CONTROLLERS (ASC)

- A. Application Specific Controllers shall be stand-alone, microprocessor based Direct Digital Controllers with sufficient memory to handle its operating system, database and programming requirements.
- B. The Application Specific Controller shall be pre-programmed, tested and factory mounted on the mechanical equipment to ensure reliability.
 - 1. Where factory mounting is not possible, the controllers shall be factory programmed and tested prior to shipment to the jobsite. The controllers shall be clearly labeled

as to controller type, where it is to be installed, and software address (if applicable).
The controller shall be fully tested upon installation to ensure that it is properly matched to the equipment it is controlling.

- C. The controller shall communicate with other devices on the communication network and be fully integrated with the other system components.
- D. The controller shall have a display and keypad for local interface with the mechanical equipment. Display and keypad are not required for fan coil units and blower coil air handlers.
 - 1. A keypad shall be provided for interrogating and editing data and the display shall be LCD.
 - 2. An optional system security password shall be available to prevent unauthorized use of the keypad and display.
 - 3. A keypad and display shall be mounted on the unit it is controlling.
 - 4. A portable service tool is acceptable, but must be permanently mounted at the location specified for the keypad and display. No exceptions will be permitted.
- E. The hardware shall be suitable for the anticipated ambient conditions.
 - 1. Controllers used outdoors and/or in wet ambient shall be mounted within waterproof enclosures, and shall be rated for operation at -40F to 155F.
 - 2. Controller used in conditioned ambient shall be mounted in dust-proof enclosures, and shall be rated for operation at 32F to 120F.

2.7 CUSTOM APPLICATION CONTROLLERS (CAC)

- A. The Custom Application Controllers shall provide stand-alone control and require no additional system components for complete operation. It shall have sufficient memory to support its operating system, database, and programming requirements.
- B. All programming required for operation shall be memory resident and shall be retained in permanent memory. Battery backup for a minimum of 72 hours is also permissible.
- C. The Custom Application Controller shall be configured such that the Operator Interface can be plugged directly into it or within sight for programming, editing, and other operator functions.
- D. The controller shall have a display and keypad for local interface with the mechanical equipment.
 - 1. Keypad shall be provided for interrogating and editing data and the display shall be LCD.
 - 2. An optional system security password shall be available to prevent unauthorized use of the keypad and display.
 - 3. A portable service tool is acceptable but must be permanently mounted at the location specified for the keypad and display. No exceptions will be permitted.
- E. Controller hardware shall be suitable for the anticipated ambient conditions.

1. Controllers used outdoors and/or in wet ambient shall be mounted within waterproof enclosures, and shall be rated for operation at -40F to 155F.
2. Controller used in conditioned ambient shall be mounted in dust-proof enclosures, and shall be rated for operation at 32F to 120F.

2.8 INPUT/OUTPUT INTERFACE

- A. Hardwired inputs and outputs may tie into the system through System Application, Custom Application, or Application Specific Controllers. Slave devices are also acceptable. Any critical points requiring immediate reaction shall be tied directly into the controller hosting the control software algorithm for the critical function.
- B. Binary inputs shall allow the monitoring of on/off signals from remote devices. The binary inputs shall provide a wetting current of 12MA at 12VDC to be compatible with commonly available control devices.
 1. All status points shown on the point list shall be positive proof differential pressure or current sensing binary switches.
- C. Analog inputs shall allow the monitoring of low voltage, current, or resistance signals and shall have a minimum resolution of 0.1% of the sensing range. Analog inputs shall be compatible with, and field configurable to commonly available sensing devices.
- D. Binary outputs shall provide a continuous low voltage signal for on/off control of remote devices.
- E. Analog outputs shall provide a modulating signal for the control of end devices. Outputs shall provide either a 0 to 10 VDC or a 4 to 20 milliampere signal as required to provide proper control of the output device as indicated on the points schedule.

2.9 AUXILIARY CONTROL DEVICES

- A. Thermostats:
 1. Electric thermostats for heating and ventilation control applications shall be line or low voltage type suitable for the application with SPDT switch action for on-off heating/cooling control or modulating type as required. Low voltage type shall have adjustable heat anticipation. Ratings shall be adequate for the applied load. Thermostats shall have exposed setpoint and temperature indication, cover, and Allen head screws. Provide thermostat for cabinet unit heaters with concealed set point and temperature indication, cover, and Allen head screws.
 - a. Thermostat Guards: Provide clear lockable thermostat guards in all publicly utilized spaces (i.e. corridors, cafeterias, gymnasiums). Provide metal wire guards in gymnasiums.
- B. Insertion Freeze Protection Switch (Freezestat):
 1. Electric switch shall be capillary type. Provide special purpose insertion thermostats with flexible elements a minimum of 20 feet in length for coil face areas up to 40

square feet. Switch contacts shall be rated for motor starter circuit voltage being interrupted. Switch shall be equipped with auxiliary set of contacts for input of switch status to digital controller. Provide additional elements or longer elements for larger coils at the rate of 1 foot length of element per 4 square feet of coil. Serpentine capillary in a plane perpendicular to the air flow to uniformly sense the entire airflow. A freezing condition at 18 inch increments along the sensing element shall activate the thermostatic switch. Switch shall require manual reset after activation.

C. Duct Smoke Detectors:

1. Duct smoke detectors shall be provided and powered under Section 16721. Controls contractor shall mount and wire to fan circuit.

D. Valves:

1. All valves shall be cage guided and provided with equal percentage modulating plugs, renewable composition disc especially compounded for water service to assure tight seating and operators equipped with molded rubber diaphragm. The plug shall be designed to provide an equal percentage relationship between valve lift and valve flow at a constant pressure drop. Three-way valves shall be equipped with modulating type plug assemblies, and shall have one seat machined integral with the body and the other with the three-way valve end. Valves shall be sized as shown on the drawings or as required to guarantee sufficient size to meet the cooling or heating requirements with specified pressure drops. Water valves shall be sized for 3 psi pressure drop where not otherwise indicated on drawings by Cv value. Valves 2 inches and smaller shall have screwed connections and valves 2-1/2 inches and larger shall have flanged connections. Control valve actuators shall be of the electric type.

E. Dampers:

1. Dampers are provided with equipment where indicated. Controls contractor is responsible for providing opposed blade control dampers mounted in ductwork.
2. Damper actuators shall be electrically operated having reversible proportional shaft output with spring return in the event of power interruptions. Operator rods with a bracket arrangement located outside the air stream whenever possible. All damper actuators shall be of the sufficient size to operate their respective dampers effectively. Where two or more dampers are to be operated by the same controlling instrument, or where the damper is to operate in sequence with another control device, each damper actuator shall be furnished with spring return.

F. Actuators:

1. All automatically controlled devices, unless specified otherwise elsewhere, shall be provided with electric actuators sized to operate their appropriate loads with sufficient reserve power to provide smooth modulating action or two-position action and tight close-off. Where two or more actuators are to be operated in sequence with each other, sequencing shall be by spring range, or by digital sequencing with separate analog outputs, as specified in the sequence of operation.

G. Transformers:

1. Provide step-down transformers where control equipment operates at lower than line circuit voltage. Transformers serving individual heating, ventilating, and air conditioning units shall be fed from the nearest distribution panel board or motor control center, using circuits provided for the purpose. Transformers, other than transformers in bridge circuits, shall have primaries wound for the voltage available and secondaries wound for the correct control circuit voltage. Size transformers so that 80 percent of the rated capacity equals the connected load.

H. Control Relays:

1. Shall be double pole, double throw (DPDT), UL listed, with contacts rated to the application, and enclosed in a dust proof enclosure. Relays shall be socket type, plug into a fixed base, and be replaceable without need of tools or removing wiring.

I. Transmitters:

1. Electronic temperature transmitters shall be RTD type, nickel wound with 0.1% accuracy over the full scale. Elements shall be for duct, outside, or insertion with separable well as required. No calibration or adjustments shall be required at the element location.

J. Sensors:

1. Outside Air Temperature: Minimum analog input accuracy shall be $\pm 0.5\%$ of full scale. Outside air temperature sensors shall be RTD type with a minimum range of -20 degrees F to 120 degrees F. The sensor shall provide a 4-20 ma output with adjustable span of zero. Thermistors may not be used for outside air temperature sensing. Provide element with sun shade to minimize solar effects. Mount sun shade at least 3 inches from building outside wall. Sun shade shall not inhibit the flow of ambient air across the sensing element. Shade shall also protect sensing element from snow, ice, and rain.
2. Space Temperature: Minimum analog input accuracy shall be $\pm 0.5\%$ of full scale. Room temperature sensors shall be RTD type with a minimum range of 50 degrees F to 100 degrees F. Use 4-20 ma sensors where necessary to meet accuracy requirements. Thermistor-type sensors may be 1,000, 10,000, or 100,000 ohm. Each room temperature sensor shall contain an integral push button for occupant initiated events such as night setback override. Sensor shall also contain an override cancel pushbutton. Sensor override capability shall be activated or deactivated at the maintenance office graphic work station as required by the owner. Mechanical timers are not acceptable.
 - a. Thermostat Guards: Provide clear lockable thermostat guards in all publicly utilized spaces (i.e. corridors, cafeterias). Provide metal wire guards in gymnasiums.
3. Immersion Pipe Temperature: Minimum analog input accuracy shall be $\pm 0.5\%$ of full scale. Immersion temperature sensors shall be RTD type with a range selected for the application. Immersion temperature sensors shall be installed in brass, monel, or stainless steel wells filled with heat conducting compound. Use 4-20 ma

sensors where necessary to meet accuracy requirements.

4. Duct Temperature: Minimum analog input accuracy shall be $\pm 0.5\%$ of full scale. Duct temperature sensors shall be rigid probe RTD type with a minimum range of 40 degrees F to 150 degrees F or averaging type as indicated. Use 4-20 ma sensors where necessary to meet accuracy requirements.

K. Differential and Static Pressure Sensors and Switches:

1. Fan proof-of-flow switches shall be adjustable set point and differential pressure type. Switches shall be piped to fan discharge except where fans operate at less than one inch WC, they shall be piped across the fan. For fractional horsepower and non-ducted fans, relays or auxiliary contacts may be used. Maximum pressure rating shall be at least 10 inches WC.
2. Pump proof-of-flow switches shall be adjustable differential pressure or flow type as specified in the sequence of operation or data point summary. Devices shall be 150 psi rated except chilled water flow switches shall be provided with totally sealed vapor tight switch enclosure on 300 psi body. Differential pressure switches shall have valved manifold for servicing.

L. Accessories:

1. Provide relays, transformers, and other accessories as required to provide a complete control system that performs the indicated functions.

2.10 SYSTEM APPLICATION CONTROLLER SOFTWARE

A. System Security:

1. User access shall be secured using individual security passwords for a minimum of eight users.
2. Passwords shall have at least three levels of user access with data entry restrictions being assignable by password.
3. User logon/logoff attempts shall be recorded.
4. The system shall protect itself from unauthorized use by automatically logging off following the last keystroke. The delay time shall be user definable.

B. Alarms:

1. The Building Automation System shall provide audio, visual, contact closure, and capability to expand for remote telephone annunciation for:
 - a. Remote equipment failure
 - b. Equipment run time
 - c. Number of start/stops
 - d. Program failure
 - e. Card failure
 - f. Sensor failure
2. Each analog sensor and binary point shall be individually alarmed for values in excess of individual high/low limits or status.
3. When an alarm state is detected, the alarm shall automatically be stored and the user notified by printing the alarm message, sounding an audible tone, and flashing

an alarm message on the CRT.

2.11 COMMUNICATIONS

- A. An autodial-up and auto-answer communications utility shall allow standalone System Application Controllers to communicate with remote operator stations over Ethernet.
 - 1. Remote Alarming/Reporting:
 - a. Controllers shall automatically call/connect operator stations to report alarms, and upload historical data and reports.
 - b. In the event that the controller is unable to connect with the remote station, it shall continue to attempt communication on a predetermined interval until communication is successful. The capability shall exist to automatically switch to a backup phone number in the event communications is unsuccessful with the first number.
 - 2. Remote Operator Communications:
 - a. Operators shall be able to connect by Ethernet remote System Application Controllers and gain access to the full control, reporting, and system modification capabilities described in this specification.
 - b. The operator shall connect by Ethernet remote buildings by selecting the user-definable name associated with the building. Manual dialing is not acceptable.

2.12 ENERGY MANAGEMENT SOFTWARE

- A. Provide the following Energy Management capabilities as a standard part of the Building Automation System. Programs shall be enabled or disabled as required by the Owner.
- B. Scheduling:
 - 1. The scheduling program shall have a minimum of 32 named master schedules. Each master schedule shall have a minimum of eight day schedules (seven plus holiday).
 - 2. To these master schedules, a minimum of 24 system loads (HVAC equipment etc) or groups of loads can be assigned.
 - 3. The master schedule shall be individually editable for each day of the week and holiday. On any day, a minimum of six time of day events may be edited including:
 - a. equipment start/stop
 - b. optimum start/stop
 - c. occupied/unoccupied
 - d. duty cycle start/stop
 - e. night purge cycle start
- C. Optimum Start/Stop:
 - 1. An optimum start/stop program shall determine the required equipment start/stop timing by applying inside/outside temperature information to the user's time of day schedule.
 - 2. The optimum start/stop program shall run independently for each controlled load or zone.

3. The program shall automatically make adjustments to itself based on historical data.
- D. Duty Cycling:
1. The duty cycle program shall cycle a minimum of 32 pieces of equipment according to user-defined on/off patterns.
 2. User editable parameters are to include period length, off time and delay time. Program shall incorporate temperature and humidity overrides to ensure that Indoor Air Quality and occupant comfort are not compromised.

2.13 BUILDING MANAGEMENT SOFTWARE

- A. Provide the following Building Management capabilities as part of the Building Automation System.
- B. Timed Override:
1. A timed override program shall be provided to enable the building operator to set up devices or groups of devices to be temporarily turned on for a defined period of time based on binary inputs, analog inputs, or CRT inputs.
 2. The override time shall be adjustable from 1 to 720 minutes.
 3. A standard weekly and monthly report shall be provided for easy documentation of timed override operation.
- C. Direct Digital Control:
1. The Direct Digital Control program shall allow modulating control of remote devices based on sensed data.
 2. Standard control strategies shall include proportional, proportional plus integral, and proportional plus integral plus derivative control.
 3. Control routines shall be flexible enough to allow operator to set parameters and make adjustments.
 4. Direct Digital Control loop setup and modification shall be done through pre-formatted edit screens, with parameters listed in English language.
 5. Program shall include a dynamic graphic display printout routine to indicate the status and real-time performance of the control loop.
- D. Custom Programming Language:
1. A custom control language capability shall be provided to allow the operator to create real time, equation based, custom control routines.
 2. All binary and analog points in the Building Automation System shall be available as inputs to the custom routines.
 3. Equation operations shall include math functions such as addition, subtraction, multiplication, division, square root, minimum, maximum, and average. Logical functions such as greater than, less than, equal to, not equal to, less than or equal to, greater than or equal to, variable timing and delays shall also be allowed.
- E. Run Time Maintenance:

1. The system shall monitor equipment status and generate maintenance messages based upon user designated run time, starts and/or calendar date limits.
2. A minimum of 32 separate devices shall be monitored under this function.

F. Expanded Messages:

1. The user shall be able to define a minimum of ten 34 character messages for automatic printing in the event of system alarm and/or run time and maintenance events.

G. Reports and Logs:

1. The system shall include the capability to store, review and print the following reports and logs. In addition, if a PC interface is specified, these reports shall be saved to diskette as an ASCII file for use by other owner furnished software packages.
2. Current Summary Report - An instantaneous summary of building status including heating and cooling degree days, on and off peak electrical demand performance, current electrical KWH consumption, and summary for critical temperature sensors listing today's minimum and maximum values.
3. Monthly Summary Report - An end of the month summary of building status including heating and cooling degree days, on and off peak electrical demand performance, current electrical KWH consumption, and summary for critical temperature sensors listing this month's minimum and maximum values.
4. Monthly Demand Limiting Report - A report for logging the electrical demand performance (both on and off peak), and the KWH consumption for each of the two utility meter programs shall be provided to the building operator. Included shall be the times of today's and yesterday's demand peaks as well as the time and date of the monthly demand peaks. This report shall log electrical performance for the present day and previous 32 days.
5. Yearly Demand Limiting Report - A report for logging the electrical demand performance (both on and off peak) and KWH consumption for each of the two utility meter programs. This report shall log electrical performance for the present month and previous 12 months.
6. Yearly Meter Report - A report for logging the electrical KWH consumption for up to 6 submeters. This report shall log electrical performance for the present month and previous 12 months.
7. Yearly Degree Day Report - A current month and previous 12 month summary of heating and cooling degree days.
8. Weekly Temperature Report - A previous 7 day summary of the minimum and maximum temperatures for the critical zone temperature sensors.
9. Weekly Override Time Report - A previous 7 day summary of after hours override usage (in hours and minutes) for the timed override groups.
10. Monthly Override Time Report - A current and previous month summary of after hours override usage (in hours and minutes) for the timed override groups).
11. Trend Logs - A custom report generator allowing the user to trend and store at least 24 sample points based on a user-defined schedule.
12. Event Logs - The system shall track system events including alarms, logons and diagnostics.

13. Input/Output Status Reports - This reporting tool shall allow the operator to review the status of all system points.
14. HVAC Equipment Reports - Reports shall be provided which indicate the HVAC equipment status as well as the status of all input/output points of connected HVAC equipment.
15. Custom Report Capability - The building operator shall be provided with a simple method of creating custom reports.

H. Anti-Recycle Timer Protection:

1. A software program shall be provided to allow each individual piece of HVAC equipment to be individually programmable with "minimum on", and "minimum off" timers to protect HVAC equipment from rapid cycling due to system or operator error.
2. Minimum on/off timer program shall have priority over all application software functions except fire shutdown and smoke evacuation modes.
3. For system start-up purposes, timers shall be set at 15 minutes or at an acceptable time as documented by the HVAC equipment supplier.
4. Timers shall be individually programmable from 0 to 120 minutes.

I. Custom Programming Requirements:

1. A user-friendly custom DDC programming utility shall be provided to allow the building operator to tailor the system to meet individual needs and respond to changing building requirements.
2. The building operator shall be able to create custom DDC routines using analog and binary point values, alarm states, constants, and shared variables to perform calculations. The results of these calculations shall be used to perform analog control, binary control, DDC loop enable/disable, and other control functions.
3. Custom routines in distributed controllers shall be maintained in nonvolatile memory to prevent loss in a power outage. Custom routines hosted in Systems Applications controllers may use battery backup so long as a quick method of system downloading is provided.
4. Additional graphics shall be approved by Mechanical Systems Coordinator at School Plant.

2.14 CONTROL WIRING

- A. The wiring for all control devices is low voltage (24V) twisted shielded pair or twisted pair or line voltage (120V) as applicable to the device. All wiring must be installed in conduit unless otherwise noted.
- B. Each wire termination shall be labeled and wiring diagrams are to be provided for the entire system.

2.15 ELECTRIC WIRING

- A. The control contractor shall furnish and install all electrical control and interlock wiring required for the automatic temperature control system furnished hereunder. All power wiring shall be furnished and installed under Division 26 and 27, including power to Direct Digital

Control System field panels and controllers and wiring to control transformer primaries.

- B. All electrical work performed under this section shall comply with the National Electrical Code, Underwriters' Laboratory where applicable and the Electrical Division of these specifications. Class II wiring for the automatic control system may be run without conduit provided the conductor insulation or jacket is designed for that purpose, and provided it is protected from physical damage. All control wiring in mechanical spaces must be in metallic conduit. Power line carrier devices may not be used. All system components and sensors must be hard wired.

2.16 VARIABLE FREQUENCY MOTOR DRIVES

The variable frequency drive (VFD) shall convert 240 or 460 volt (+/- 10%), three phase, 60 hertz (+/- 2Hz), utility grade power to adjustable voltage/frequency, three phase, AC power for stepless motor control from 5% to 105% of base speed.

A. Description

The variable frequency drive (VFD) shall produce an adjustable AC voltage/ frequency output for complete motor speed control. The VFD must meet all of the following criteria:

1. The VFD shall use sine coded Pulse Width Modulation (PWM) technology. The sine coded PWM calculations are performed by the VFD microprocessor.
2. The VFD shall use Insulated Gate Bipolar Transistors (IGBT) transistors for the inverter's three phase output.
3. The VFD shall use a three phase diode bridge converter to charge the VFD constant voltage capacitor buss.
4. The VFD shall have the ability for control by either a remote 4-20 mA control signal or from a local control panel located on the VFD itself.
5. The VFD shall use microprocessor technology for VFD control. The VFD shall be programmable with a permanently mounted keypad included with each VFD.
6. The VFD shall be fully self diagnostic. No external programmers, analyzers, interrogators, or diagnostic boards, shall be needed to annunciate VFD faults or drive internal status.

B. Code Standards

VFD shall be UL listed as delivered to the end user. The VFD shall meet current National Electrical Code.

C. VFD Quality Assurance

To ensure quality, each and every VFD shall be subject to a series of in-plant quality controlled inspections before approval for shipment from the manufacture's facilities.

1. All components shall be tested prior to assembly and the complete unit shall be tested under full load conditions to ensure maximum product reliability.
2. The VFDs shall be the current standard production unit with at least 10 identical units already in the field.
3. Engineering support shall be available from the factory of the VFD. Phone support

shall be free of charge to the end user for the life of the equipment. Factory support shall be available in the English language.

D. VFD Service

The VFD shall be supplied with:

1. 24 month parts and labor warranty. The warranty shall start when the system is accepted by the end user or 30 months from date of shipment.
2. Installation, operation, and troubleshooting guide(s).
3. A district service support group shall provide the following additional services:
 - a. Factory trained personal on-site for start-up for up to one working day at no additional cost. Personnel shall be competent in operation and repair of the particular model of VFD that is installed.
 - b. On-site training of customer personnel in basic installation, troubleshooting, and operation of VFDs at no additional cost. This training shall be conducted for up to 6 personnel at the installation site for a minimum of 4 hours.

E. Basic VFD Features

The VFD shall have the following basic features with no more than three separate internal electronic boards.

1. VFD mounted operator control keypad capable of:
 - a. Remote/Local operator selection with password access.
 - b. Run/Stop and manual speed commands.
 - c. All programming functions.
 - d. Scrolling through all display functions.
2. Digital display capable of indicating:
 - a. VFD status.
 - b. Frequency.
 - c. RPM of motor.
 - d. Phase current.
 - e. Fault diagnostics in descriptive text.
 - f. All programmed parameters.
3. Standard PI loop controller with input terminal for controlled variable and parameter settings made while inverter running.
4. User interface terminals for end-user remote control of VFD speed, speed feedback, and isolated form C SPDT relay energized on drive fault condition.
5. An isolated form C SPDT auxiliary relay energized on run command.
6. The VFD shall have a metal NEMA 1 enclosure.
7. The VFD shall have an adjustable carrier frequency with 16 KHz minimum upper limit and 2 KHz minimum lower limit.
8. The VFD shall have a built in or external line reactor with 3% minimum impedance to protect DC buss capacitors and rectifier section diodes.

F. Programmable Parameters

The VFD shall include the following operator programmable parameters:

1. Upper limit frequency.
2. Lower limit frequency.
3. Acceleration rate.
4. Deceleration rate.
5. Variable torque volts per Hertz curve.
6. Starting voltage level.
7. Starting frequency level.
8. Display speed scaling.
9. Enable/disable auto-restart feature.
10. Enable/disable soft stall feature.
11. Motor overload level.
12. Motor stall level.
13. Jump frequency and hysteresis band.
14. PWM carrier frequency.

G. Protective Circuits and Features

1. An electronic adjustable inverse time current limit with consideration for additional heating of the motor at frequencies below 45Hz, for the protection of the motor.
2. An electronic adjustable soft stall feature, allowing the VFD to lower the frequency to a point where the motor will run at FLA when an overload condition exists at the requested frequency. The VFD will automatically return to the requested frequency when load condition permit.
3. The VFD will have a separate electronic stall at 110% VFD rated current and a separate hardware trip at 190% current.
4. The VFD shall have ground fault protection that protects output cables and motor from grounds during both starting and continuous running conditions.
5. The VFD shall have the ability to restart after the following faults:
 - a. Overcurrent (drive or motor).
 - b. Power outage.
 - c. Phase loss.
 - d. Overvoltage/Undervoltage.
6. The VFD shall restart into a rotating motor operating in either the forward or reverse direction without tripping or damaging the VFD or the motor.
7. The VFD shall keep a log of a minimum of four previous fault conditions, indicating type and time of occurrence in descriptive text.
8. The VFD shall be able to sustain 150% rated current for 60 sec.
9. The VFD shall respond to and record the following fault conditions:
 - a. Over current (and have an indication if the over current was during acceleration, deceleration, or running).
 - b. Overcurrent internal to the drive.
 - c. Motor overload at start-up.
 - d. Over voltage from the utility power.
 - e. Motor running overload.
 - f. Overvoltage during deceleration.
 - g. VFD over heat.
 - h. Load end ground fault.
 - i. Abnormal parameters or data in VFD EEPROM.

H. Operational Conditions

The VFD shall be designed and constructed to operate within the following service conditions.

1. Ambient Temperature Range, 15 to 120 deg. F.
2. Non-condensing relative humidity to 90%.
3. Vibration – 0.6G maximum.

I. Available Options

Provide the following options:

1. RFI/EMI filters
2. RS232 or RS422/485 interface card with application software which can both control and monitor the VFD from attached computer.
3. A manual bypass circuit and switch integral to the drive to allow drive bypass and operation at 100% speed. Overload fuses and other protective hardware shall remain in the circuit during bypass.
4. UL listed disconnecting means.

2.17 SEQUENCE OF OPERATION

Refer to drawings.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install all items in accordance with the manufacturer's instructions.
- B. The control equipment and wiring shall be installed in a neat and workmanlike manner. All wiring and conduit shall be run parallel to or at right angles to the building structure, and shall be concealed in all finished spaces.
- C. Thermostats, wall switches, and wall timers shall be located as shown on drawings and mounted at the indicated height above finished floor. Devices shall be mounted in metal wall boxes.
- D. Install control valves in vertical position whenever possible, and in no case shall control valves be installed below a horizontal position.
- E. Install control panels in an approved location, convenient for adjustment and service.
- F. The BCS contractor shall enter all computer programs and data files into the related computers including all control programs, initial approved parameters and settings, and English descriptors.
- G. The BCS contractor shall maintain diskette copies of all data file and application software for reload use in the event of a system crash or memory failure. One copy shall be delivered to

the owner during training session, and one copy shall be archived in the BCS contractor's local software vault.

3.2 VALIDATION

- A. The BCS contractor shall completely check out, calibrate and test all connected hardware and software to insure that the system performs in accordance with the approved specifications and sequences of operations submitted.
- B. Witnessed validation demonstration shall consist of:
 - 1. Display and demonstrate each type of data entry to show site specific customizing capability. Demonstrate parameter changes.
 - 2. Execute digital and analog commands.
 - 3. Demonstrate DDC loop precision and stability via trend logs of inputs and outputs.
 - 4. Demonstrate EMS performance via trend logs and command trace.

3.3 VERIFICATION OF HVAC CONTROL SYSTEM

- A. The TAB agency shall coordinate with and be assisted by building controls contractor in verifying the operation and calibration of all HVAC and temp control systems. Verify all components are installed in accordance with project requirements and are functional including all electrical interlocks, damper sequences, air and water resets, fire and freezestats and other safety devices.
- B. TAB Support: Coordinate onsite meetings with TAB Contractor for DDC manipulation during TAB procedures.

3.4 MANUALS

The following manuals will be provided:

- A. An Operators Manual shall be provided with graphic explanations of keyboard use for all operator functions specified under Operator Training.
- B. Computerized printouts of all DCP data file construction including all point processing assignments, terminal relationships, scales and offsets, command and alarm limits, program flowcharts, etc.
- C. An As-Built Manual shall be provided including revised as-built documents of all materials required under the paragraph "SUBMITTALS" on this specification.
- D. Two Operators Manuals, and two As-Built Manuals shall be provided to the owner.

3.5 TRAINING

- A. All training shall be by the BCS contractor and shall utilize specified manuals and as-built documentation.
- B. Operator training shall include three four-hour sessions encompassing:

1. Sequence of Operation review.
2. Selection of all displays and reports.
3. Use of Operators Interface.
4. Troubleshooting of sensors (determining bad sensors).
5. Password assignment and modification.
6. The first training session shall be prior to building occupancy. The second session shall be 30 days after building occupancy. The third session shall be three months after building occupancy.

3.6 WARRANTY

- A. All components, system software, parts and assemblies supplied by the BCS contractor shall be guaranteed against defects in materials and workmanship for one year from acceptance date.
- B. Labor to troubleshoot, repair, reprogram, or replace system components shall be furnished by the BCS contractor at no charge to the owner during the warranty period.
- C. All corrective software modifications made during warranty service periods shall be updated on all user documentation and on user and manufacturer archived software disks.
- D. Provide four 4-hour sessions during the warranty period for program modifications desired by owner or additional training.

END OF DIRECT DIGITAL CONTROL SYSTEM